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Integrating biodiversity offsets within Circular Economy policy in China

Mustafa Ali [a, b, *], Christina M. Kennedy [c], Joe Kiesecker [c], Yong Geng [a, b]

[a] School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China
[b] Global China Institute for Urban Governance, Shanghai Jiao Tong University, Shanghai 200030, China
[c] Global Lands Program, The Nature Conservancy, Fort Collins, CO 80524, USA

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ABSTRACT

China aims to realize the aspiration of sustainable development using the Circular Economy (CE) policy which, apart from other objectives, aims to minimize raw material extraction and preserve natural resources. While CE can be an important policy tool to promote more sustainable development trajectories, in practice it does not always avoid or mitigate adverse impacts on biodiversity and ecosystem services caused by resource extraction and infrastructure development. Here we review the current status of biodiversity protection and CE policy in China, highlighting some of their challenges. We then explore the prospects for market-based biodiversity offsets to address the current shortcomings in existing CE policy. Finally, we propose a conceptual model that incorporates a commitment to no-net-loss mitigation into the overall CE strategy to expand the use of biodiversity offsets in China and to remove some of the deficiencies by involving private enterprises in conservation efforts. This model can be used to analyze a set of parameters for comparing different offsets against one another. We propose that such an integrative framework can help CE policy achieve the intended goal of decoupling economic growth from impacts on biodiversity and ecosystem services in China. Important next steps are the implementation of case studies for target industries and ecosystems to demonstrate the synergy between CE and biodiversity offsets and evaluate on-the-ground effectiveness of the proposed integration by adapting our framework.

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1. Introduction

China is one of the most biodiversity-rich countries with 13.7% of the total vertebrate species and the third largest inventory of the vascular land plant species in the world (Ministry of Environmental Protection (2010)). Many of the species in China are endemic and endangered (Liu, 2013), and yet China has experienced the loss of 90% of the grasslands and 11.5% of the wetlands in recent decades (Ministry of Environmental Protection (2010)). Drivers species and habitat losses include rapid industrial and urban development, which in turn has resulted in serious pollution, inefficient resource utilization, and health damage costs in China (Xie, 2009). Associated problems in affected areas include decreasing ground water levels (Han et al., 2016), desertification (Cheng et al., 2016), loss of biodiversity (Güneralp and Seto, 2013), deterioration in soil quality (Kuzyakov et al., 2016), and the loss of farmland (Song and Liu, 2016). Some examples include loss of 40.69 km^2 of forest to urban development in Qin-Ba mountainous area (Xu et al., 2016); loss of 760 km^2 of wetland in the Pearl river delta between 1992 and 2012 due to urban expansion (He et al., 2014); and loss of loss of critical habitats for 46 endemic species due to a cascade of 10 hydroelectric dams on the Yangtze river (Yang et al., 2013). The ecological footprint per capita in China has continuously increased over the last few decades (Borucke et al., 2013) and is currently 3.4 global hectares, which is greater than the world average of 2.84 global hectares (Global Footprint Network, 2014).

A decoupling of economic growth, resource use, and environmental impact has yet to occur in China (Geng et al., 2016). Hence, there is a strong need for policies that can protect or compensate for environmental degradation caused by agricultural, industrial and urban development (Yang et al., 2017). In this paper, we discuss how market-based biodiversity and ecosystem services offsets could be put into place through effective policy-making in coming

* Corresponding author. School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China.
E-mail address: mustafa@sjtu.edu.cn (M. Ali).

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years. Ecosystem services refer to the goods and services provided by natural processes and components to, directly or indirectly, satisfy human needs (De Groot et al., 2002). Biodiversity can enhance functions that ultimately lead to different ecosystem services, e.g. wetlands can aid water purification as well as provide habitat for fish for human consumption. In China, ecosystem services are seen with an anthropocentric view, where overlapping interests of humans and nature are regarded in addition to the intrinsic value of nature itself (Ahlheim et al., 2015). In the Chinese sustainability policy context, the government aims to improve the generation of ecosystem services, promote the establishment of eco-compensation mechanisms, and strengthen ecosystem monitoring and research (Chen et al., 2013).

In our opinion, these objectives can be achieved by aligning them with other policies for resource conservation in China, in particular Circular Economy (CE) policy. CE aims to preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows; optimise resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles and foster system effectiveness by revealing and designing out negative externalities (MacArthur, 2013). Since 2003, several national laws and regulations have been enacted to facilitate the implementation of CE in China and the size of the enabling environmental industry has been estimated to be ~USD $750 billion (Xiaoxue Weng, 2015). While biodiversity preservation is integrated within the CE concept, examples are lacking that demonstrate a clear link between CE and biodiversity protection. Moreover, in spite of CE policy, China has been losing biodiversity across the country, which indicates that the current policy needs a revision to resolve such issues.

Existing literature on CE focuses on assessing operational issues such as waste minimization through supply chain efficiency and industrial symbiosis. Thus, in the absence of any direct or clear link between successful implementation of CE (in its present form) and biodiversity protection, new solutions for improved conservation should be explored. Such policies should, in addition to the three R's of reduction, reutilization and recycling espoused by CE (Murray et al., 2017), also avoid, minimize, restore and/or offset environmental impacts of developmental projects (Kiesecker et al., 2010). Since CE has been offered as a system for the accounting of natural resources and ecosystem services, ecological compensation, and market-based instruments for environmental management in China (Geng et al., 2016), it only makes sense to incorporate in CE a system that ensures demonstrable financial and legal commitment towards biodiversity protection. In this paper, we discuss market-based biodiversity offsets in terms of their ability to act as such a device within the overall CE framework. By involving market levers into conservation activities, the Chinese government can help ensure that individual companies are held accountable for the impacts from their economic activities.

We aim is to show how biodiversity offsets could be put into place through effective policy-making. First, we describe the current status of biodiversity protection in China. Next, we explore biodiversity offsets as a market oriented tool of environmental conservation. Finally, we propose a model that incorporates market based biodiversity offsets in the context of CE in China.

2. Literature review

2.1. Environmental conservation programs in China

China is signatory to several international agreements that at their core seek to protect biodiversity and ecosystem services: including the Convention on Biological Diversity (Campbell et al., 2014), the Convention on Wetlands (Kun, 2005), Convention on Migratory Species (as a nonparty member) (Luo et al., 2016), the Convention on International Trade in Endangered Species (Zhou, 2015), International Convention for the Protection of New Varieties of Plants (Ross and Zhang, 1999), the Intergovernmental Platform on Biodiversity and Ecosystem Services (Honglie et al., 2014), among others. China also has a set of laws targeting environmental protection with Environmental Impact Assessment included in their provisions which cover forests, grasslands, wildlife, natural reserves and water and soil protection. (Liu et al., 2015b). Moreover, China has adopted different strategies for biodiversity protection. Some of the Chinese planning initiatives include the China Biodiversity Conservation Strategy and Action Plan, the National Environmental Protection Plan, and a dedicated National Council for Biodiversity Conservation that is responsible for overall coordination of national biodiversity conservation activities (Zhao et al., 2015). China has also established an 'ecological red line' that demarcates ecological hotspots in the country for conservation (Bai et al., 2016). So far, China has established 2541 nature ecological preserves across different parts of the country, which cover around 15.3% of its total territory (Ministry of Environmental Protection (2010)).

In China, ecological compensation through biodiversity offset schemes has been established in the recently updated Law of Environmental Protection (State Environmental Protection Administration, 2006). Such schemes are collectively known as *shengtai buchang jizhi*, which translates as ecological compensation and comparable to Payment for Ecosystem Services (PES) schemes in other parts of the world (Zhen and Zhang, 2011). While PES schemes in developed countries are meant to achieve net gains in ecosystem services, in China, such programs are used to halt further loss of biodiversity and ecosystem services (Pan et al., 2017). Most of the ecological compensation/PES schemes in China are Pigouvian and serve to pay the costs of restoring degraded ecosystems (He and Lang, 2015). Either a fee is levied to reduce negative externalities or compensations in different forms are distributed for the provision of positive externalities (Schomers and Matzdorf, 2013). Since private property in China is rare, many of the beneficiaries and stewards of PES schemes include local governments.

One of the prominent PES schemes in China includes the Sloping Land Conservation Program (SLCP) (Deng et al., 2016; Liu and Henningsen, 2016). SLCP was launched in the wake of droughts and floods to halt soil erosion by converting cropped area on slopes and terraces in hilly areas into forests. The farmers are compensated through grain subsidies, which are monetized using current grain prices for in-kind offsets (Bennett, 2008). Similarly, the Natural Forest Protection Program (Liu et al., 2008) serves to conserve forests by banning logging, and affected parties in this case are compensated through cash payments. Funding for the program is provided by the central government (81.5%) and local governments (18.5%) (Liu et al., 2008). Compensations are determined on the basis of direct expense of replantation and the opportunity cost of forest protection. Chinese PES schemes also include watershed management programs, which usually involve financial payments from the downstream beneficiaries that use the water and/or the upstream polluters that drain waste items in the water. Prominent examples include the Watershed Eco-compensation Program (Bennett, 2009) and the Water Use Rights Transfer (Liu, 2003) scheme. Payments are determined on the basis of opportunity cost upstream, cost of infrastructure and water consumed downstream. China also has projects and incentives for controlling soil erosion and promoting eco-agriculture. Examples include Four Wastelands policy that auctioned wasteland for farming (Ho, 2003), soil erosion control fees and Soil & Water Conservation Installation Compensation Payments (Zhen and Zhang, 2011). Compensations in this case are based on the cost of environment rehabilitation. Similarly,

the government provides subsidies for 'green' initiatives, such as biogas production (Sun et al., 2014). Other schemes include compensation for residents' migration near dams, water diversion projects, or other infrastructural development (Wilmsen, 2016). The government also has developed different schemes and programs that encourage green procurement activities (Zhu et al., 2013). The goal, scope and time scale of each of these PES schemes varies. For instance Water Use Rights Transfer scheme had a total budget of RMB 2.77 billion of which RMB 1.14 have been invested so far; SLCP has a total budget of RMB 337 billion and it has enrolled 9.27 million hectares of cropland so far; National Forest Protection Program has a targeted forest area of 68.2 million hectares of forest with a budget of RMB 96.2 billion (Zhen and Zhang, 2011).

The above discussion demonstrates that the *modus* for all Chinese PES programs involves one or more government departments and that most of these schemes involve compensations, fines, and subsidies. Lack of a real market mechanism, involving value and time trade-offs, raises questions about the long-term effectiveness and viability of these PES schemes. Critics have pointed out that some of the nature preserves in China are "paper parks" and do not meet conservation goals (Quan et al., 2011). For instance, the SLCP program has been criticized for having insufficient funds, exaggerated results to receive promotions, lack of coordination between finance and forestry bureaus, lack of technical support and, in some cases, counterproductive results (Yeh, 2013). Moreover some of the PES schemes in China have been discovered to neglect stakeholders' rights and obligations (Long et al., 2015). They have also been criticized for their limited local stakeholder participation (Zheng and Cao, 2015), posing financial burden for many local governments resulting in budget crises in some cases (Kolinjivadi and Sunderland, 2012), and for having negative socio-economic costs like unemployment and poverty (Liu et al., 2008). Moreover, there is often divergence in central (ecological) and local (economic) governments' interests (Yu and Wang, 2013). Many of these centrally-planned conservation policies remain partially implemented at the local level (Kolås, 2014). The existence of many of these programs is likely to be threatened in the event of the removal of government subsidies, and many local farmers indicate an intention to return to crop-plantation once the subsidy period ends (Bennett, 2008). Thus, the long-term sustainability of these programs is doubtful in the absence of a market mechanism and the onset of a slowing economy in China.

2.2. Circular Economy policy in China

Apart from the PES schemes and programs described above, China has adopted different policy mechanisms geared toward sustainable development (Liu et al., 2014b). Circular Economy (CE) is one of the major policy tools that have been employed to reduce waste, conserve natural resources and protect biodiversity and ecosystem services. CE focuses on the three Rs of Reduction, Reutilization, and Recycling across different production processes to make them more lean, green and cost effective (Liu et al., 2017). Currently, scientific literature on CE policy in China focuses on its effectiveness in improving production efficiency by stimulating cleaner production at the firm level, promoting industrial symbiosis at the industrial cluster level, and establishing eco-industrial networks at the regional level (Zhang et al., 2010). Studies show that a projected $600 billion has been committed to information technology, clean energy, environmental protection, scientific research and innovation (He et al., 2012). While the economic potential of CE policy has generally been acknowledged (Geng et al., 2013), critics have criticized the presently used indicators of CE for failing to account for the benefits provided by nature, including biodiversity and ecosystem services (Geng and Doberstein, 2008; Geng et al., 2013).

The main ministries involved in the documentation of CE include State Environmental Protection Administration (SEPA) (now called Ministry of Environmental Protection, MEP) and National Development and Reform Commission (NDRC) (Zhang et al., 2010). Both of these institutions have developed evaluation systems for CE relying on different sets of economic and environmental indicators. The Chinese government has adopted a national Circular Economy Evaluation Indicator System with two sets of indicators: one is used for macro-level general evaluation of regional development through CE and the other is focused on CE development at Eco Industrial Parks. Both of these indicator systems focus on four categories, including resource output, resource consumption, integrated resource utilization, and waste disposal/pollutant emission indicators (Geng et al., 2012). Within these categories, lower resource consumption is implied as demonstrating fewer impacts on natural ecosystems. However, the indicators used for tracing resource consumption measure only energy and water use and do not account for impacts of resource extraction on biodiversity or ecosystem services.

Apart from the shortcomings in the indicator system, critics also argue that the economic objectives of CE will always trump those pertaining to conservation given that its success depends upon support from the industry and the local bureaucracy who prioritize economic objectives (Yu and Wang, 2013). It has been reported that some of these officials falsify information, shut down pollution control equipment, and secretly reopen closed factories to promote economic objectives at the expense of environmental goals (Wang, 2013). To counter this, the Chinese government has tried to rebalance the appraisal system in favor of environmental protection by aligning them with economic targets (Cao et al., 2016). This has been done, for instance, by focusing on projects involving renewable energy sources, such as wind and solar (Zheng et al., 2015). Consequently, air pollutants have decreased overall, while other environmental problems, such as water pollution, continue unabated (Liang and Langbein, 2015). Similarly, steps have been taken for the establishment of total economic value of all ecosystem products and services in its different regions for the establishment of a Gross Ecosystem Product (GEP), which in turn can be used for performance appraisals (Asian Development Bank, 2015). However, so far, only a few pilot studies have been carried out for the GEP in areas such as Ordos, Xing'an, Tonghua City, and Xishui County (IUCN, 2017). Hence a comprehensive strategy coupling biodiversity and ecosystem protection with market-based economic instruments is still missing in the appraisal system.

In short, while CE is intended to support resource conservation, it actually falls short in ensuring that losses to biodiversity and natural capital do not occur during development. We assert that by utilizing market-based biodiversity and ecosystem service offsets (explained in the next section), the Chinese government can make individual companies more accountable for impacts associated with their economic activities. By pairing biodiversity offsets with CE gains, these companies can also increase their profits while shouldering some of the financial burdens of conservation activities.

2.3. Integration of biodiversity offsets in Circular Economy policy

The basic premise of CE is continuous restoration and replenishment of resources through the 3R principle of reduce, reuse and recycle (Murray et al., 2017). Since production and development operations involve natural resources, such as habitats and ecosystem services, in principle CE should include their restoration so as to sustain adequate stocks of natural capital. A framework of

market-based biodiversity offsets can assist CE by compensating for impacts on such resources with the goal of achieving a "no net loss" or preferably a "net gain" outcome (Rainey et al., 2015). In order to determine no net loss or net gain, the resources need to be identified or characterized on the basis of multiple criteria evaluation framework. As an example, offsets for ecosystems such as forests can be evaluated on the basis of place-specific environment, distinctive history and complex ecological processes and interactions all taken together (Moreno-Mateos et al., 2015). Similarly, habitat compensation for species such as fish can be evaluated on the basis of factors such as Periphyton biomass, invertebrate density, fish biomass, and riparian vegetation density (Quigley and Harper, 2006). Biodiversity offsets are often used to describe different market-based instruments for protecting ecosystem services as well as biodiversity and may include examples such as mitigation banking, habitat banking, and species banking, different PES schemes, among others (Hrabanski, 2015). These schemes suggest that in order to mitigate the impact of development, a set of offsets should be available which could be evaluated and compared on the basis of a set of criteria or parameters. For this paper, we identified such parameters after a thorough literature review on biodiversity offsets precedents across different countries.

2.3.1. Need and scope identification

Many researchers have stressed the importance of identifying the need of biodiversity offsets themselves. In some biodiversity hotspots, such as those in Western Cape province of South Africa, offsets are mandated by the law (Brownlie and Botha, 2009) whereas in other cases they are voluntary (Ten Kate et al., 2004). Existing studies usually recommend offsets only when prior application of avoidance, minimization, and remediation measures have been exhausted (McKenney and Kiesecker, 2010; Quintero and Mathur, 2011). Researchers also stress the importance of proper evaluations rather than ad hoc determination of the scale and scope of the offsets. Pertinent questions include: Should poverty reduction be included in the scope of the offsets? (McAfee, 2012); Should offsets be in-kind or out-of-kind? (Overton et al., 2013); Should offsets be in-situ or ex-situ? (Kiesecker et al., 2009; Koziell and Swingland, 2002), etc. Hence the need and scope identification should be the first step in determining offsets.

2.3.2. Stakeholder identification

Closely associated with the scope for offsets is the identification of relevant stakeholders that are directly or indirectly affected by planned development and the mitigation of environmental damage (Facility, 2012; Jonas et al., 2014). Some researchers have criticized the neo-liberal tendency of alienating or dispossessing local communities from interacting with the sites of impact and development (McAfee, 2012). Therefore, it is important to consider the impact of the prioritization of different offset schemes on indigenous communities and to be careful to ensure socially equitable outcomes (Mandle et al., 2015). Here socially equitable outcomes refer to sharing rights and responsibilities, risks and rewards associated with a project, and to offset in a fair and balanced way while simultaneously respecting legal and customary arrangements (Poulton, 2015). The selected projects may not result in the best set of ecosystem services for each local community equally. This is especially important due to the involvement of intermediaries in market based offsets who might lead "*highly variable and often ineffective project by project approach to offset supply, with minimal commitments*" (Quétier et al., 2014). The long term impact of offsets on local communities as well as the public at large also needs to be ascertained to avoid political conflicts and to ensure viability of such projects (Wilcox and Donlan, 2007). In other words, a mismatch between the people bearing the costs of development and those enjoying the benefits of offsets should be resolved (Schreckenberg et al., 2017). Successful examples of stakeholder participation in environmental protection include Desertification Mitigation and Remediation of Land (DESIRE) in the EU (Reed, 2008) and community-based ecotourism management at tourist destinations in Thailand (Pornprasit and Rurkkhum, 2017).

2.3.3. Legal and financial considerations

Researchers suggest that the viability of offset schemes should be determined in terms of both financial and legal commitments (Niner et al., 2017). Appropriate transaction costs of the offsets and the underlying institutional arrangements need to be established (Coggan et al., 2013). Standards need to be established to define baseline biodiversity declines and net gains in biodiversity and ecosystem services (Gordon et al., 2015b). On the basis of these standards, different offset alternatives can be compared to one another. Transparent and participatory multi-criteria decision support systems should be used to evaluate different offset scenarios (Rogers and Burton, 2017; Sheppard and Meitner, 2005). Such criteria can include technical factors such as ecological equivalency, cumulative biodiversity and ecosystem services gains, offset mechanisms, etc., (R. Lansley, 2015) as well as the socio-economic needs of different stakeholders (Bullock et al., 2011), (Williams et al., 2003).

2.3.4. Options for offset creation

Offsets can be created by both individuals and companies. Examples of the former include the Bush Broker and Native Vegetation Offsets program in Victoria Australia where credits are created through conservation gains from protection, maintenance of quality, and improvement of native vegetation by the landlords (Alvarado-Quesada et al., 2014). Similarly, in Satoyama, Japan rice fields have been used as habitat for White Storks resulting in increase in tourism and organic farming as well as creation of offsets each of which pays 7000 Japanese Yen per 1000 m^2 (Sukhdev, 2017). Companies can undertake large-scale projects, such as protecting breeding habitats for endangered animals, maintaining forest and wetland parks for tourism, repairing and maintaining cultural sites. Examples of companies creating offsets include mitigation banking in the USA where oil and mining companies such as Chevron have developed credits through the maintenance and preservation of wetlands (Kantor, 2013). Table 1 provides some examples of offsets in other countries that can be adapted in China according to the local conditions.

2.3.5. Determination of credits

Once offset(s) has been selected, credits similar to transfer development rights (Pruetz and Standridge, 2008) can be generated against them. These credits can then be sold by the offset creator to the prospective developers. The consequence of this whole exercise should ideally be an enhancement in biodiversity and ecosystem services i.e., a net gain. Quantification of this gain should be carried out to discover the difference between the intended and actual results. Different offsets can be compared with each other in terms of relative marginal returns in relation to the predefined goals and objectives. While there are no standard practices for establishing offset to impact mitigation ratios, common current practice is to define offsets in habitat area units (Tallis et al., 2015). For instance, an environmental and social impact assessment (EISA) conducted by the World Bank recommended using habitat hectares to determine offsets to compensate for the impact of mining sector on forests (Group, 2015). General guidelines are available for selecting sites and determining scales (Kiesecker et al., 2009). These guidelines blend landscape conservation planning with the mitigation hierarchy and then select an

Table 1
Examples of biodiversity offset schemes.

Case study	Offset creator	Offset tool	Reference
Wetlands			
IDOT wetland mitigation sites, Illinois.	Illinois Department of Transportation.	Restoration and creation of wetlands.	(Matthews and Pociask, 2015)
Wetland mitigation, North Carolina.	Mitigation banks, Department of Transportation and private permittees.	Restoration and creation of wetlands.	(Hill et al., 2013)
Paradis wetland mitigation bank, Louisiana	Chevron-Texaco oil company.	Creation of wetland on former drilling site.	(Stewart, 2016)
Forests			
Longleaf pine habitat, Southern USA.	Private landowners.	Contractual easements for conservation.	(Singh et al., 2016)
Littoral forest, Madagascar.	Rio Tinto mining company	Creation of five legally protected areas under Madagascar law.	(Virah-Sawmy et al., 2014)
Guaraqueçaba Climate Action Project, Brazil.	American Electric Power Corporation, Chevron-Texaco and General Motors.	Regeneration and restoration of natural forest and pastureland.	(Swingland, 2013)
Habitats			
African great apes habitat, different countries.	Simfer mining, Cameroon; Lom Pangar Hydropower Project, Cameroon; Emirates Global Aluminum (EGA), Republic of Guinea; Bumbuna Hydroelectric Project, Sierra Leone.	The hydroelectric projects proposed construction of national forest parks. Simfer mining proposed construction of additional and protection of the current habitat. Information from EGA was unavailable.	(Kormos et al., 2014)
Bale Mountains National Park, Ethiopia.	Ethiopian Wildlife Conservation Authority.	Conservation of grasslands for Mountain Nyala.	(Mamo et al., 2010)
Allensworth Ecological Reserve, California.	Wildlands Inc.	Conservation of San Joaquin kit foxes.	(Cypher et al., 2013)

offset based on the residual impacts of development activities. Based on these principles, specific tools for offset selection can vary from case-specific mathematical models (Moilanen et al., 2009) to generic software approaches (Mandle et al., 2016). Indices such as emergy ratios can be used to denominate the material and energy flows in the whole system in common units (Brown and Ulgiati, 1997) and to compare biodiversity offsets in spatial planning. These ratios have been used for valuating natural capital of countries (Sweeney et al., 2007), appraising ecosystem services (Huang et al., 2011), accounting for CE indicators (Chen et al., 2005), and identifying the ecological impacts of land use change (Watanabe and Ortega, 2014). Other similar indicators include tools to measure ecological integrity (Theobald, 2013), landscape development intensity index (Brown and Vivas, 2005), etc. Similarly, Life Cycle Impact Assessment techniques use a host of categories to analyze the environmental impact of an activity on ecosystem quality, human health, natural resources, climate change, among other attributes (Owsianiak et al., 2014). With the utilization of the concept of emergy, as adopted under the CE, these categories can be expressed and compared along a common scale. The offsets can also be compared on the basis of their effect on food, energy and water nexūs (Biggs et al., 2015).

3. Conceptual model to integrate biodiversity offsets within CE in China

Based on our literature review, we propose a model that includes the above described parameters in an effort to facilitate the integration of biodiversity offsets within CE in China. As discussed earlier, biodiversity offsets are typically used as part of the mitigation hierarchy, where practitioners first seek to reduce impacts through avoidance or minimization and then through restoration and finally offsets. Hence CE and mitigation frameworks are similar with the avoid/minimize steps complementing the reduce role in the CE and the restoration step complementing CE's reuse phase. We argue in favor of a framework that combines biodiversity offsets in the overall CE agenda in China. The model for such a market-based offset creation is explained below within the context of CE (Fig. 1).

It can be seen from Fig. 1 that in CE as resources are consumed they need to be continuously replenished using the 3R principle. However, if a resource cannot be recycled completely, the impact of its consumption on the finite stock of critical natural capital needs to be mitigated. Here natural capital refers to ecosystems' capacity to provide goods and services and critical natural capital is one which cannot be substituted in the provision of these functions by socio-economic gains or industrial/urban development (Ekins et al., 2003). The offsets used to mitigate the impact are determined on the basis of a set of parameters as discussed in the previous section, and are further explained in a Chinese context below.

3.1. Need and scope definition

The first parameter in offset creation is the identification of the need and delineation of the scope of biodiversity offsets. When delineating the system boundaries for environmental impact assessment (EIA) for a diverse country such as China it is important to take landscape-scale perspective (Kiesecker et al., 2010) (rather than a narrow, project-scale) to fully account for the direct, indirect, and cumulative impacts of development on ecosystems and biodiversity (Kennedy et al., 2016). The EIA should use a multi-criteria approach including factors such as baseline conditions of habitats, species and ecosystem services on the site as well as the enabling conditions which support them, their socio-economic values, legal status of the site and impact assessment which in turn can be assessed on the basis of its magnitude or amount, extent or area, time duration and whether the change is permanent or reversible (IEEM, 2006). The scope of an impact will vary the

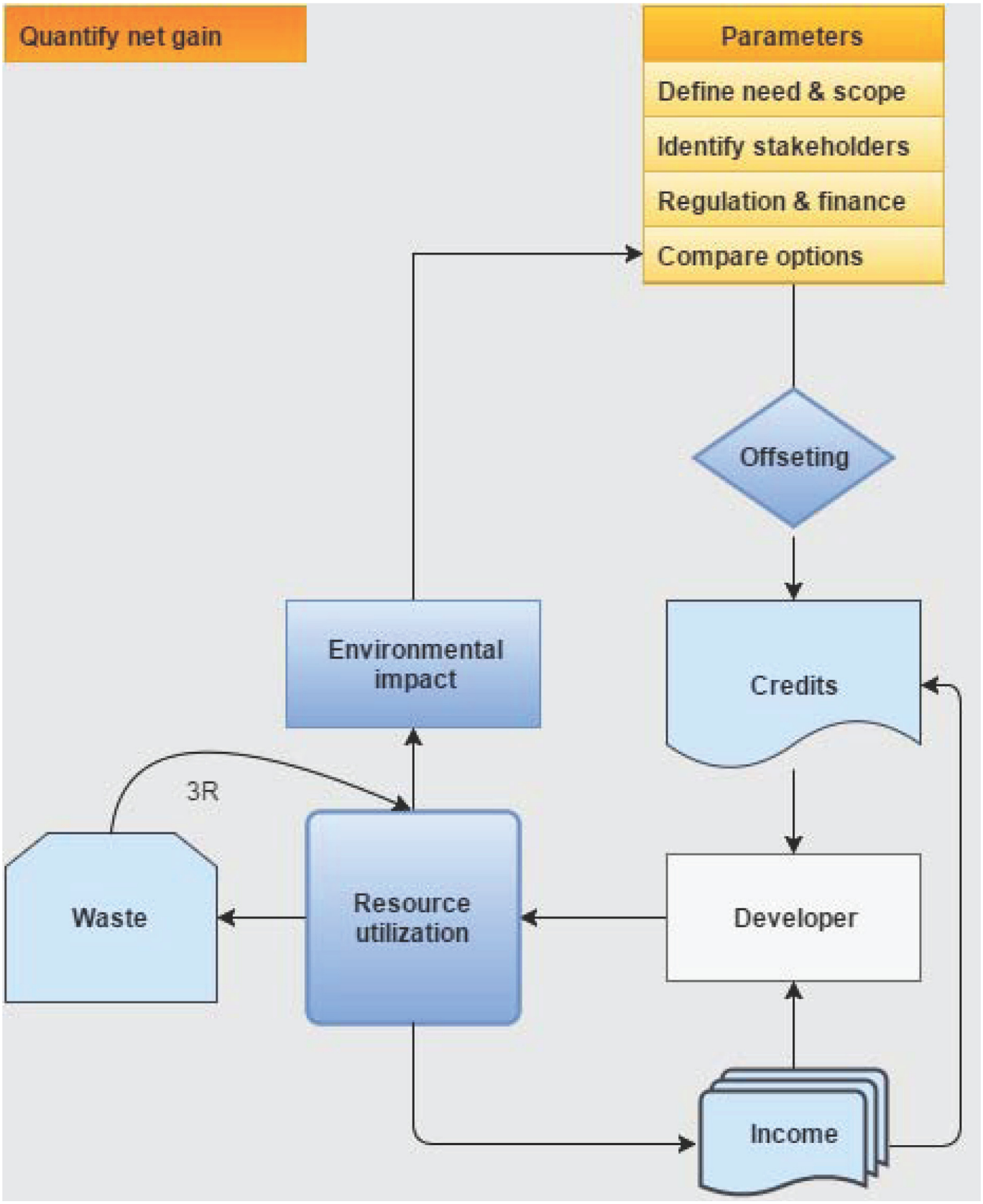

Fig. 1. Comparison of circular economy and mitigation hierarchy.

type of ecosystem under consideration. For instance, the impact of highway development on wetlands are measured in terms of habitat loss, degradation and isolation which in turn are determined through the species' density at the impact site (Cuperus et al., 1999). Similarly, the impact of off shore wind farms on marine ecosystems in can be determined by measuring reef effect and reserve effect (Vaissière et al., 2014).

3.2. Stakeholder identification

In addition to ecological considerations, the consequences of both the siting of development and the offset actions for local communities need to be considered to ensure socially equitable outcomes (Jørgensen et al., 2007; Tallis et al., 2015). The impacts of prioritization of offset schemes can vary from one indigenous community to another depending upon their location within China. This can be resolved by encouraging local stakeholders to participate in the decision making process leading to a transparent offset scheme. Relevant data required for this includes information regarding social and spatial boundaries, rules about extracting resources, labor, materials, and financial considerations for management of the sites of impact and mitigation (Ban et al., 2013). In order to encourage local solutions, power-interest matrices can be used to identify and engage all stakeholders inclusively in the decision-making process. For instance, the attitudes of different stakeholders towards conservation of medicinal plants in Meru Betiri National Park, Indonesia were assessed using a power-interest matrix and the results suggested incorporation of economic interests of loggers in the overall conservation strategy (Nurrochmat et al., 2017). Similarly, the attitude of a panel of Pakistani environmental specialists towards Chinese Foreign Direct Investment (FDI) in Pakistan was analyzed using power-interest matrix and it was discovered that the stakeholders had reservations regarding air quality and water consumption which needed to be alleviated (Huang et al., 2017). In China it might also be useful to see *Nature* itself as a stakeholder to avoid its excessive commodification and compartmentalization.

3.3. Regulation and finance

Meeting the regulatory and financial requirements of the offsets scheme is the third parameter in our model. In China, the Committee of Environmental Protection and Natural Resources Conservation serve as the authority of legislative supervision whereas Ministry of Environmental Protection and the National Development and Reform Commission serve as the authorities for environmental supervision and integrated management, respectively (Li and Qin, 2014). According to China's current legislation, compensation still takes the form of fines with financial ceilings (Liu and Zhu, 2014). For the establishment of market-based biodiversity offsets, the respective Peoples' Congresses at provincial/municipal levels can play a crucial role in the development of a bottom-up legislation for mandatory and voluntary offsets. For instance, in the case of conservation banking in the USA, California was a pioneer in trading species credits; based on this precedent, the policy was adopted federally only in 2003 (Fox and NINO-MURCIA, 2005). Audits should be conducted to monitor easements, environmental goals, and socio-economic outcomes of the offsets. To carry out such audits, site specific data would be necessary and as such the concept of GEP as discussed in Section 2.2 can be used here. Local level bureaucracy can be aided by independent researchers in such audits and evaluations.

Regarding finance, the factors of time, scale, level, source, value and the payer should be identified as key parameters (Parker et al., 2012). To support the potential investors there should be a provision of special credit schemes from banks and other financial institutions coupled with favorable tax arrangements. The Chinese government can also set aside a special fund for all parties interested in advance mitigation. These funds and schemes can take advantage of the Green Credit Guideline of the Chinese government that encourages banks to give more loans to environmental friendly companies than to others (Guo, 2014). The investors can be categorized with entrepreneurs working on small offset schemes and commercial organizations, such as financial institutions undertaking large projects. Competitive bidding for the pilot projects can be undertaken through a supranational environmental stock exchange modeled on the emissions trading exchange system already being used in China (Liu et al., 2015a). The valuation of the offsets should be transparent and case-specific. Moreover the financial instruments for empirical calculations should always involve a complete valorization of biodiversity (Bracking, 2012) and ecosystem services (Tallis et al., 2016).

3.4. Environmental impact and comparison of offsets

We note that as individual indices fail to account for the dynamic interplay between different organisms; hence multi-criteria approaches are required to accurately account for biodiversity and related ecosystem services impacts and benefits (Grant et al., 2008). Consequently, researchers have developed Essential Biodiversity Variables (EBVs) that define a minimum set of measurements that capture major dimensions of biodiversity change. These variables have been divided into six classes i.e. “genetic composition,” “species populations,” “species traits,” “community composition,” “ecosystem structure,” and “ecosystem function” (Pereira et al., 2013). This system has been developed by the Group on Earth Observations Biodiversity Observation Network and 22 variables have been identified that aim at providing a balanced picture of biodiversity at a location (Vihervaara et al., 2017). In China, 564 optimized sites have already been identified that can be used for monitoring of the EBVs by the China Biodiversity Observation Network (Xu et al., 2017). Researchers suggest that some of the EBVs can also be monitored from space using remote sensing thus reducing the costs and the need for laborious measurements taken on the ground (Maron et al., 2015b). Hence, EBVs provide a practical and meaningful tool for monitoring biodiversity and ecosystem service losses. It is also important to consider the caveat that a complete feedback of a biodiversity offset may come after a long period of time. Thus, simulation tools and decision support systems can evaluate different alternatives and scenarios beforehand in tandem with the EBVs to evaluate offsets. Such models can be used to make predictions at different levels of biological complexity, from species and communities to habitat or ecosystem types (Honrado et al., 2016).

3.5. Offsetting and credit generation

Once an offset has been selected, it must be ‘created’ in a manner consistent with the legal, technical and financial requirements in China (BBOP, 2012; Wilkinson et al., 2002). Once the offset has established quantified gains, it can be floated in the form of a credit for sale on a trading floor similar to the carbon exchanges currently in use in major cities such as Shanghai, Tiangjin and Beijing (Zhang et al., 2014). These credits can be bought by developers and companies as certificates for their commitment towards environmental conservation. In our framework, the credits should be bought by the developers using a portion of the income they gained through resource exploitation. This can help create greater recognition about the importance of natural capital in a country where economic priorities dictate most decision-making.

4. Integrating biodiversity offsets within China's CE schemes: the Eco-Longmen, Living Dongjiang project

While there are no case studies that illustrate all the principles we seek to advance in our model to integrate biodiversity offsets within CE schemes in China the Eco-Longmen, Living Dongjiang (ELLD) project in Jiaquan Spring in Longmen County has several novel aspects that can help illustrate some of these principles. This project aims to protect the Jiaquan Spring, which spring is being commercially used by Danone Waters China (DWC) for its YILI bottled water brand. DWC teamed up with International Union for Conservation of Nature (IUCN) to help restore part of the watershed on which Jiaquan Spring depends for sustainable drinking water (IUCN, 2017). Jiaquan watershed has been polluted due to expanding economic and urban development and the project aims to mitigate this through restoration of local watershed in Longmen County as a demonstration project. The Jiaquan watershed covers three provinces namely Yunnan, Guangxi and Guanzhou. The ELLD project focuses on Longmen County in Guangzhou province. The project sought to ascertain the full impact of economic activity on the Jiaquan watershed as a whole, and then narrow it down to the local ecosystem in Longmen County. Water sample tests were utilized to assess the level of pollution and habitat degradation caused by industrial and urban development on the watershed as a whole. The socio-economic, aesthetic, cultural and legal conditions served as local scale impacts in the EIA specific to of the watershed in Longmen County. Similarly, while the scope of the project constitutes restoration of the degraded watershed to allow clean drinking water for the local community, the rehabilitation efforts will also provide benefits to the local flora and fauna that are part of a greater eco-system and can these benefits can be quantified using tools like the EBV's or project proponents can develop additional biodiversity criteria to help guide offset requirements. As we suggest in our model stakeholder engagement needs to consider socially equitable outcomes. In case of ELLD the stakeholders include, among others, the local community in Longmen County, local governments at the county, city & and provincial levels, DWC and the end-users living downstream from the county. To ensure socially equitable outcomes, the project aims to reduce the impact of local communities on water while simultaneously helping them improve their socio-economic status. To achieve this end, the project focuses on supporting local farmers in developing and producing Eco-rice, orchard and honey. Since the ELLD project is legally a demonstration project, successful implementation may lead to its replication in other locations. Moreover, while the project is being financially supported by the Danone Ecosystem Fund, it's monitoring and evaluation are being carried out by government as well as non-governmental organizations including IUCN (ChinaDaily, 2015); meeting the need for 3rd party appraisals. Finally, ecological farming activities can help maintain the initial project investments given the prevalence of these activities in Longmen County. Ultimately, the ELLD project will implement offset activities that include restoration of 43 ha of secondary forest, 10 ha of green crops and setting up a water training school for waste water and drinking water management. While the project is being labeled as a way “to strengthen and develop the activities of the partners who make up Danone's ecosystem” (Danone ecosystem, 2017)” it might be more useful to call out the fact that these activities act as a compensation for pollution and over-use in the watershed. Such a label can help add a sense of obligation and liability to these activities. Finally once implemented the actions can be measured against the minimum offset requirements suggested by the EIA so it can be determined whether ELLD actions are adequate. If actions are deemed to have a net gain, the additional value of the offset can be sold to other companies in the form of TDRs. In the future, this project can be further enhanced to include local industrial and municipal wastewater filtration/recycling to enable an even more ‘circular’ flow of water resources in the local economy.

5. Discussion

Some scholars have termed the 21st century as the Chinese century (Shenkar, 2013). At the same time that China has grown economically, it faces serious environmental issues such as pollution and loss of biodiversity and ecosystem services. Apprehending industrial pollution here is problematic as it is feared that it might check economic growth. About half of China's municipalities' current revenue depends on real estate development, thus, increasing pressures on food security and habitat conservation (Yale School of Forestry and Environmental Studies (2013)). Yet, the increasingly vocal middle class in China is demanding a better standard of living and hence a cleaner environment. Existing industry examples that attest to Corporate Social Responsibility (CSR) activities in the realm of biodiversity conservation within China include labeling of rare plants and animals in construction zones by China State Construction Engineering Bureau, a 2-year investment of RMB 40 million by China Minsheng bank to protect fishing resources and afforestation efforts by Industrial and Construction Bank of China (An, 2015). However, it must be noted that only 4.7% of the top 100 companies in China have been found to disclose substantial information about their CSR activities and for about 50% of the companies, CSR reports have low coverage of reported indicators and are marked by a gap in responding to stakeholder requirements (Dong et al., 2014). As Chinese companies increase their economic footprint, our proposed framework can help them meet their environmental goals. This can be achieved through offsets that can be monitored and measured in both ecological and economic terms and reported more meaningfully. For instance, even though SLCP program has led to afforestation of more than 100,000 square miles of land in South Western China, most of these trees are monoculture plantations of Eucalyptus and Aspen which have little value for native habitats (Zhai et al., 2014). Our model removes this discrepancy by using EBVs that account for baseline conditions, the complete impact of development and match them with the required offsets. This can help companies meet the objectives of CSR activities in a more tangible way with a set of benchmarks to measure their performance against. This is especially important in the mining industry of China where site reclamation rates are less than 20% and incomplete in most cases, thus causing local ecosystems to become unstable and degraded within a few years (Lei et al., 2016). Having no net loss of biodiversity and ecosystem services among the corporate goals can make mining industry seek preemptive solutions for the eventual restoration efforts.

As previously discussed, in China, environmental goals at local levels risk being sacrificed in favor of economic objectives. The Chinese government has tried to combine both goals through incentives and subsidies in areas, such as renewable energy, electric vehicles, green labeling, etc. We assert that market forces can also be used to promote conservation of biodiversity and ecosystem services in the private sector. Moreover, offsets have the potential to alleviate poverty, create a significant economic market (Swartz, 2016; Trends, 2015) and to provide alternative employment opportunities through activities like tourism (Su et al., 2014), organic farming (Liu et al., 2014a), conservation services (Yi et al., 2014), etc. Moreover, despite the potential shortcomings of offset implementation, the polluter/developer pay principle espoused in our model is expected to encourage conservation efforts. For instance, by internalizing negative externalities through offsets can lead to more environmentally responsible decision making in the industry.

Reflecting the cost of the offset in the final price of the goods and services can also make consumers make more responsible choices. The model presented in Fig. 1 is intended to show that since offsets can help preserve habitats and biodiversity, ecosystem services can continue to be used in biological cycles thus contributing towards CE. Practical examples include constructed wetlands that can be used for land reclamation or waste water treatment while preserving biodiversity (Zedler, 2003), waste composting used for waste disposal while providing ecosystem services of soil erosion control and maintenance of natural cycles (Basta et al., 2016), preservation of biodiversity for cultural or nature-based tourism (Martin-Lopez et al., 2008), etc. Specific examples in other countries include the $10 million Nairobi Water Fund which involves water fund-led conservation interventions by companies such as Coca Cola with an expected return on investment of $21.5 million USD in economic benefits over a 30-year timeframe (Conservancy, 2015).

As China aims to move from export-led growth to one based on consumption (Guo and N'Diaye, 2009), the development of value added goods and services will be essential. Biodiversity offsets have the potential to act as a value added financial service (PricewaterhouseCoopers, 2010), as well as for guiding corporate environmental stewardship (Rainey et al., 2015). Moreover, infrastructure and industry development are still primarily controlled by the Chinese government. So it can be presumed that the major clients for these offsets will be government institutions. Thus, they might provide a lever to increase national-level environmental stewardship for meeting some of the Sustainable Development Goals including that of Responsible Consumption and Production (Löhr et al., 2017). Offsets might also address the claims of unjust land grabbing (Ong, 2014; Sargeson, 2013), if local farmers can be incentivized to create habitat offsets and to receive income in addition to the compensation for their land acquired for development purposes (Wandesforde-Smith et al., 2014). Offset creation can also be outsourced to specialists to prepare and/or preserve a habitat preemptively. Thus, an assortment of offsets can be in place as the need for mitigation arises. An advantage of such advance offsetting is that already restored or created banks can reduce or eliminate the lead time and time lag between the impact of development and the establishment of a new offset (Esty, 2007).

Biodiversity offsets have faced rising criticism (Gibbons and Lindenmayer, 2007), however, the debate centers on issues related to the adequacy of compensation actions rather than the importance of compensatory mitigation itself (Bendor, 2009). Some argue that the provision of offsets will not halt biodiversity declines as the goal of an offset is usually to neutralize only the loss attributable to a particular development (Maron et al., 2015a). It should also be noted that the need for biodiversity offsets in itself is an admission of failure (Maron et al., 2015c), and without early mitigation their might be substantial global reductions in biodiversity and ecosystem services (Warren et al., 2013). Concerns are also raised regarding the adequacy, consistency, and transparency of credit calculations (Bracking, 2012). This is especially important when determining the biodiversity baseline against which offsets are measured and credits are calculated (Maron et al., 2012). Moreover, offset schemes might compete with voluntary environmental conservation efforts, as well as the rights of indigenous communities (Sylvester et al., 2016). Such perverse incentives might crowd out community volunteers and result in false public confidence in offset activities due to marketing efforts (Gordon et al., 2015a). Thus, there exist various technical, social, ethical, and governance challenges in successfully implementing biodiversity offsets and every situation calls for circumstantial evaluation (Maron et al., 2016), (Githiru et al., 2015).

6. Conclusions

In order to conserve natural resources, the Chinese government has initiated different measures including CE. Under the current CE policy, the Chinese government aims to improve the generation of goods and services provided by ecosystems (termed ecosystem services), enhance coordination among levels of government to reconcile conservation with development, and promote eco-compensation mechanisms (Chen et al., 2013). However, CE falls short of mitigating for biodiversity and ecosystem service losses to local communities. In this paper, we argue that aligning these objectives with other sustainability policies for resource conservation in China, in particular biodiversity offsets, would help address the currently unaccounted impacts on natural habitats and their associated biodiversity and ecosystem services. First, we reviewed the current status of biodiversity protection and CE policy in China, highlighting some of their shortcomings. Next, we explored biodiversity offsets as a market oriented tool for conservation. We proposed a model that incorporates market-based biodiversity offsets in the context of CE, thereby enabling the Chinese government to better ensure that individual companies are held accountable for the impacts from their economic activities. In our proposed framework, the performance of offsets can be tracked and forecasted over time to allow the government to analyze the results of pilot programs to evaluate future policy options. With the intent that, in due time, a synergy between environmental protection and economic growth can be achieved.

A limitation of this research is a lack of sufficient real world examples that demonstrate the efficacy of our model. For the case study of ELLD provided above, further improvements need to be made for it to more clearly demonstrate CE leading to biodiversity and ecosystem services conservation. This example was meant solely to display the possibility of using biodiversity offsets within the existing CE policy. Rather than treating PES and CE schemes and policies as distinct from one other, we argue, that there is a need to integrate them to meet conservation goals. We hope that this is the first step in a series of articles that explore the topic in further detail, particularly as case studies become available.

In our opinion decision makers need to think holistically and implement policies that can, at least, halt the decline in the quality of ecosystems in the country. In this article, we have presented a model that attempts to strike a balance between conservation efforts and developmental projects in China. Further research is needed to develop a comprehensive indicator system that can give appropriate weights to economic and environmental goals of different urban and industrial projects in the country. Moreover, the market needs to be involved in conservation efforts so as to make the private sector more cognizant of its responsibilities towards the environment. The model presented in this paper goes beyond post-hoc fines and penalties and attempts to make conservation goals as one of the necessary outcomes of developmental projects. As such this research can be considered as one of the first steps pointing a need for establishing the necessary links between CE and biodiversity conservation in China.

China is considered to be the manufacturing center of the world, with its scale of construction and development disproportionately large. With new initiatives such as the One Belt One Road project, China plans to relocate its excess manufacturing capacity in other countries. Thus, policy changes in this country is expected to have global repercussions. This is precisely why it is crucial that sustainable development be rooted, promoted, and supported here. Thus, there is a need to conduct studies that take into account China's growing economic role and its corresponding environmental footprint in future studies. Further research inputs are needed from economists as well as environmentalists before an

inclusive and practical policy can be developed and implemented.

Conflict of interest

The authors declare no conflict of interest.

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